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Microscopium Pantometricum ;
O R,
A New CONSTRUCTION of a
MICROMETER,
ADAPTED TO THE COMPOUND AND SOLAR
MICROSCOPE:

SHEWING BY INSPECTION,

- I. The *Magnifying* Power of the *Object Lenses*,
and of the *Eye-Glasses*.
- II. The EXTENT of the FIELD of VIEW.
- III. The DIMENSIONS of the *Real* and
Apparent Magnitude of small Objects.

TO WHICH IS ADDED,

The DESCRIPTION of an *Universal*
PERSPECTIVE, with a Scale of all its
Magnifying Powers.

The Whole illustrated by Two COPPER-PLATES.

By B. MARTIN.

L O N D O N.

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P R E F A C E.

I Confess I am almost deterred from any further Publication on Microscopes, Micrometers, Telescopes, &c. after so many Tracts that I have wrote and troubled the Public with for Forty Years past, on those Subjects. But if it be criminal to be thus constantly scribbling, both Nature and Art are to be blamed; for, by Nature, I have a great Aversion to Idleness, and as strong a Propensity to the Study and Improvement of the philosophical Sciences and Instruments. And if any such Improvements are made, how are they to be explained without writing upon them?

Again—So vast is ART, so narrow human Wit—that it is impossible to see through all her Mazes and Intricacies at once—Day unto Day adds Knowledge—I have often wondered that what at present seems so plain, I could avoid observing seven Years ago. Science is progressive, and it would be presumptuous to suppose we can exhaust or finish any one Subject.

Amongst all the different Forms and Denominations of Microscopes hitherto published, there still remains one more to be described, which I have here entitled, *The PANTOMETRIC MICROSCOPE*; or, *A Microscope so constructed with a MICROMETER, that it shews at Sight the Magnifying Power, the Dimensions of Objects, and the Extent of the Field, without the least Trouble to the Artist.* I thought, therefore, I might be indulged if I entreated, once more, the Attention of the Public to an Explanation of it.

As it is equally applicable to the Solar MICROSCOPE, in a portable Form, and the essential Parts consisting of a single and compound Microscope, the Whole may be considered as a New Apparatus, or SYSTEM of Optical Instruments, whose Expence is small, if compared with its extensive Uses.

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But the principal Inducement to the present Publication, was the Consideration that a MICROMETER of a more simple and easy FORM, and less expensive, was very much wanting in MICROSCOPES; for if DEXTERITY on one hand, and (the much more important Article) MONEY on the other, be wanting, all the present Micrometrical INVENTIONS will be of but little Avail.

This may, probably, be the last Thought I shall entertain of the Forms, Kinds, and Construction of Optical INSTRUMENTS, besides one that is now ready for the Press, which is entitled Uraniscopium Magnum, the Grand URANISCOPE, to answer all the Purposes of an Equatorial TELESCOPE, and Solar-Disk MICROSCOPE, by CLOCK-WORK, and Planetary Pendulum; but as this is a Work of quite a new Complexion, it will in this Age meet with little Encouragement; and therefore I shall bequeath it to the ingenious Part of Posterity, at such an Æra, when Mathematical PHILOSOPHY shall once more raise its Head, and be esteemed the most honourable Branch of Literature.

I have added to this Tract, the DESCRIPTION of an Universal PERSPECTIVE of the Reflecting Sort, and exemplified its various USES, and Magnifying POWERS, for the Sake of the young Optical CONNOISSEUR of TASTE, who alone will thank me for it. For it is a general Observation, that in all other Cases besides Literature, People think they never can have too much for their Money.



A NEW



A NEW CONSTRUCTION OF A MICROMETER,

APPLIED TO THE COMPOUND AND SOLAR
MICROSCOPE.

I HAVE always judged a MICROSCOPE extremely imperfect and defective without a MICROMETER; for tho' it be granted, that the Improvement of the *Natural Sight* by the Microscope be prodigiously great; yet that is, perhaps, not half the Advantage which may be derived from such an inestimable Discovery: for what can be a greater Point of Curiosity, or tend more to expand the narrow Limits of the *Human UNDERSTANDING*, than a Knowledge of the *amazing Gradations* of *diminishing MAGNITUDE* in the *Minutiæ Naturæ*, or smallest Sort of Objects? Yet their *DIMENSIONS* of every Sort are equally attainable by the MICROMETER *applied to the MICROSCOPE*, as the Forms, Colours, Motions, &c. are by the Microscope itself.

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2. It is true, indeed, that the Use of the *Micrometer* is supposed to be a Matter of mere Curiosity, and to concern only the *Virtuosi*, and Adepts in the Study of Nature; but this is judging very perversely; because the great and ultimate Design of Providence in this Discovery was, undoubtedly, to furnish the human Mind with the most perfect and exalted Ideas of the ineffable Power and Skill of the Divine Author of Nature, that it is capable of. But these Ideas are not compleat by barely inspecting those wonderful *Minutiæ*, but by adding thereto the Speculation of their just and astonishingly *small* DIMENSIONS.

3. Yet, notwithstanding this, it was long after the Invention of the Microscope, before a Word was mentioned of a MICROMETER; *Power*, *Leuwenhoek*, *Hooke*, *Swammerdam*, *Hugenius*, *Baker*, and many others who have wrote largely on this Subject, are either wholly silent about it, or mention only *Grains of Sands*, *Shreds of fine Wire*, *Lattices in Brass*, &c. by which to form a vague Judgment of the *small Dimensions* of Objects.

4. But as these uncertain Methods of *Microscopic Mensuration* gave but little Satisfaction, I published a MICROMETER made with a Screw, containing 50 Threads to an Inch, which, as it conveyed a mechanical Certainty, was very well received; and about 30 Years after I rendered it much more compleat, and gave some Directions for its Use in my *Optical ESSAYS*, Page 47.

5. Yet after all I could contrive or think of in this Way, I found the Generality even of *Connoisseurs* themselves, awkward enough at computing, as well the *magnifying Power* of the Microscope, as the *Dimension* of small Objects by the Micrometer. And, indeed, it

is



Of a MICROMETER.

is not to be wondered at, when it is considered, that the *magnifying Power* depends upon the *Thickness* of a small Lens, the very short *Radii* of its convex Surfaces, and the respective *Distances of the Object and its Image*; all which are with no small Difficulty measured, and ascertained by the most expert Optician. And as this is the Case in the most simple Construction of a compound Microscope, the *magnifying Power* can by no Means be readily defined in those that have *more than two Glasses*.

6. Those who are least experienced in the Microscopic Praxis, are very desirous of *deep Magnifiers*, and extremely inquisitive about Lenses of the shortest focal Distances; and they suppose it may be known when they are $\frac{1}{16}$, $\frac{1}{20}$, $\frac{1}{30}$, $\frac{1}{40}$, or $\frac{1}{50}$ of an Inch, as well as when they have focal Distances of 1, 2, 3, 4, or 5 Inches; but herein they are strangely mistaken; for it would puzzle a NEWTON himself, to determine precisely what is the *Solar focal Distance* of one of those very small Lenses. Nor would it boot any of these over-curious Geniuses, to be informed what the focal Distance of a *very small Lens or Spherule* really is; for they could not from thence conclude any thing in regard to the magnifying Power, or Dimension of small Objects, as they seem to expect. Nor can it answer any other Purpose than pure Curiosity that I know of.

7. Indeed the Fate of an OPTICIAN is very hard, if he be one that pretends to know any thing of the THEORY or PRINCIPLES of OPTICS; for People think to answer such Questions as these, *What is the Focus of the Lens? How many Times does the Microscope magnify? What Field of View does it take in? &c.*

A New CONSTRUCTION

Is to him not more difficile,

Than to a Blackbird 'tis to whistle.

And because it would be appearing in a bad Light, not to give the Querist some plausible Answer, tells him *the Lens is about $\frac{1}{30}$ of an Inch Focus.*——*That the Instrument magnifies 200 Times.*——But whether his Responses are rigorously true, or not, he is secure from Detection; and he knows, that, with respect to such People, he can sufficiently satisfy them, with a *Crede quod habes, et habes.*

8. But to prevent any Trouble, or Deception of this Kind, I have contrived a Method by which *Every Man may be his own Optician*, or satisfy himself in any of the above-mentioned Points, by his *Eye-sight alone*, which is usually called, *ocular Demonstration*. That is, he will be able of himself to determine

I. The MAGNIFYING POWER of *single* and *compound* MICROSCOPES.

II. The EXTENT of the FIELD of VIEW.

III. The DIMENSIONS of the smallest OBJECTS.

IV. The *Apparent* MAGNITUDE of every OBJECT.

And all this without any other Qualification than a good Eye, and the Blessing of a *common Understanding*.

9. That this new Method of Demonstration may be most easily comprehended, I suppose (1.) That an Inch is divided into *ten equal Parts*, and each such Part I call a LINE; so that one Inch is equal to *ten Lines*. (2.) That a Line is again divided into *ten equal Parts* also; and one of those Parts I call a POINT; so that ten Points make one LINE; and 100 Points make one INCH.

10. Suppose next, that a SCREW contains just 100 Threads in an Inch; then the Distance between each

two

two Threads will be one Point, and 10 Threads will make a Line.

11. Lastly ; let a small Piece of such a fine Screw be placed under the Object Lens of the Microscope, and another Piece of the same be fixed in the Focus of the Eye-glass ; and the Microscope is then completely fitted to answer all the four Purposes just mentioned, viz.

I. The MAGNIFYING POWER of the Single MICROSCOPE.

12. In order for an ocular Demonstration of this, let Fig. 1. represent the *Area of the Eye-Stop*, or circle circumscribing the View in the Microscope ; in mine, this Circle is just *six Lines and four Points* (or $\frac{64}{100}$ of an Inch) in Diameter ; and so the Piece of this Screw (*de*) which goes through the Center of the Circle, contains 64 Points ; but these viewed with the *naked Eye*, are not discernable ; when at the same Time a few of the Points, as *ab*, *bc*, of the Object Screw, will be sufficiently sensible to the Eye alone, as being largely magnified by the Object Lens.

13. Now when this small or natural Field of View is itself magnified by the *Eye-Glass*, it will appear as in Fig. 2. where the Points in the Wire, or Screw DE, are rendered sufficiently large and distinct to the Sight, and may be easily counted from one End to the other. The Points *ab*, *bc*, in Fig. 1. will now also be a *second Time magnified*, and appear very large, as in AB, and BC.

14. Hence it evidently appears, how many Times the Object Lens magnifies the Object, viz. just so many Times as there are Points of DE contained in one of the Points of the magnified Screw AB or BC ; this Number (in the Figure) is 24 ; therefore this Lens magnifies every Object equally, or 24 Times in Diameter,

meter, and so many Points or Threads of the Screw (*de*) are contained, of course, in one magnified Point (*ab*) in Fig. 1. This is the Effect of the third Magnifier in my Microscope, marked C in the Table of Article 40; to which you are referred in what follows.

15. The fourth Magnifier D makes the Image or magnified Point AB so large as to contain 48 Points of the Screw DE; and so magnifies 48 Times, or twice as much as the other.

16. The fifth Magnifier E makes the Image of one Point (*ab*) so large as to equal the Diameter (*de*) of the whole Eye-Stop; and consequently the Point AB comprehends all the 64 Points in DE, or magnifies 64 Times in Diameter. And this I find by Experience is a magnifying Power sufficient to answer most Purposes for the present natural Constitution of the Eye.

II. The *Magnifying* POWER of the *Compound* MICROSCOPE, and EXTENT of the FIELD of VIEW.

17. The second Power of magnifying by the Microscope, is by Means of the EYE-GLASS, placed at its focal Distance from the Eye-Stop in Fig. 1. For it is supposed that the Eye alone cannot discern the first magnified Points *ab*, *bc*, distinctly, at a less Distance than 8 Inches, or 80 Lines: but through the Eye-Glass, they are seen perfectly at the Distance of its *Focus*, which in that of my Microscope is 8 Lines, which is 10 Times nearer than 8 Inches; consequently the whole Eye-Stop (Fig. 1.) and all its Contents, are magnified 10 Times.

18. But 10 Times 64 is 640; the Object is therefore magnified 640 Times in Diameter with the Lens E; and its Superficies 409600 Times; and lastly its Solidity

Solidity 262144000, or more than Two Hundred and Sixty-two Millions of Times.

19. With the fourth Magnifyer D it will be enlarged 10 Times 48, or 480 Times in Length and Breadth; also 230400 Times in Superficies, and 110592000 Times in Bulk.

20. By the third Object Lens C, the magnifying Power is 10 Times 24, or 240 Times in Diameter; 57600 Times in Surface; and 13824000 Times in the solid Content.

21. The Object Lenses A and B, are designed chiefly for shewing *opaque Objects*, as the Distance between the Object and the Lens will admit of the Object's being strongly illuminated, and thereby shewn to great Perfection. And the *magnifying Power* in each of these is shewn in the same Manner as in the three first, viz. by observing how many Points in the Micrometer DE are contained in one of the magnified Points AB, and multiplying that Number by 10, as in each of the foregoing Examples.

22. Lastly, The EXTENT of the FIELD of VIEW is evident from this Consideration, that the Diameter (*de*) in the real Field (or Eye-Stop of Fig. 1.) contains 64 Points or Threads of the Screw; and this is magnified 10 Times by the Eye-Glass; therefore the Diameter of the *magnified Field of View* is equal to 640 Points, or 64 Lines; that is, equal to a Circle whose Diameter is 6 Inches, and 4 Tenths. For such a circular Piece of Paper held 8 Inches from the Eye, will appear under the same Angle, and therefore just as large as the Eye-stop appears through the ocular Lens.

23. Hence

23. Hence the general RULE for finding the Diameter of the Field of View in any Microscope is this: Divide the Diameter of the Eye-Stop by the focal Length of the Eye Glass, and multiply the Quotient by 8, the Product is the Diameter of the Field required. Therefore the Field of View, or visible Area of Objects, does not at all depend on the Magnitude of the Microscope, though it will always be found that the larger Glasses of a Microscope give a more perfect and distinct View of the Object; but on this Hand we are also limited, since the Distinctness of Vision is not in Proportion to the Size of the Glasses, but to their proper Disposition in the Instrument, as is demonstrated in my New ELEMENTS OF OPTICS. From what has been said, it follows, that when the Diameter of the Eye-Stop is equal to the focal Distance of the Eye-Glass, the Angle of Vision is a right one, and the greatest the Microscope will well bear.

III. Of the DIMENSION of small OBJECTS.

24. The Dimension, or Method of measuring a small Object, results immediately from the above described Construction of a MICROMETER DE, and the Reason thereof is evident at first Sight. For with respect to any particular Object Lens, as the 3d for Instance, you know what Part of a magnified Point AB, one Point in the Micrometer DE is, viz. $\frac{1}{24}$ Part in this Lens C; and that it is a $\frac{1}{48}$ Part in the 4th Lens D; and a $\frac{1}{64}$ Part in the 5th Lens E.

25. Nothing then now remains to know the Dimensions of an Object, but to observe how many Points in the MICROMETER DE its Image occupies, or is equal to: thus for Example; suppose with the 3d Magnifier, you see the Image of an Object just equal to one Point,

then

then you know that it is $\frac{1}{24}$ Part of AB; and also that AB is itself $\frac{1}{100}$ of an Inch; therefore every Point of DE measures $\frac{1}{24}$ of $\frac{1}{100}$, or $\frac{1}{2400}$ Part of an Inch; consequently the Object in Question is equal to $\frac{1}{2400}$ of an INCH, or $\frac{1}{240}$ Part of a LINE, or the $\frac{1}{24}$ Part of a POINT.

26. The same Object magnified by the Lens D, will have an Image equal to 2 Points in DE; and so the Measure of it will be $\frac{2}{240}$ Parts of a Line, or $\frac{1}{120}$, as before.

27. If the magnifier E be applied to the same Object, then the Image will be greater than by the 3d Magnifier in Proportion of 64 to 24, or it will occupy 2 Points and $\frac{2}{3}$ of another; and so $\frac{2\frac{2}{3}}{640}$ is still $\frac{1}{240}$ Part of a Line, as at first. Hence the same Measure or Part of a Line will be given for the Length or Breadth of an Object by each magnifying Lens.

28. Suppose, for another Example, that with the 3d Magnifier C you observe 3 equal Images of an Object equal 5 Points in the Micrometer DE; then one Image is $\frac{5}{3}$ of a Point; then 'tis plain that 5 is to 3 as 240 is to 144; and therefore the Length of the Object is $\frac{1}{144}$ of a Line.

29. Again, suppose with the same Magnifier you observe 5 equal Images of an Object just equal to 3 Points in DE; then is 1 Image equal to $\frac{3}{5}$ of a Point; then $3:5::240:400$; therefore the Object itself is $\frac{1}{400}$ Part of a Line.

30. Let 3 equal Images, contiguous to each other, be made by the 5th Magnifier E, and measure 7 Points of the Micrometer, then 1 Image will be equal to $\frac{7}{3}$ of a Point; and then $7:3::640:274$ nearly; so that

C

the

the Object belonging to that Image is $\frac{1}{274}$ Part of a Line.

31. In one of the lesser Magnifiers, as B, suppose 10 Points of the Micrometer be equal to one magnified Point AB of the Screw; then the whole magnifying Power will be 100 Times: let an Image of an Object by this Lens be equal to 13 Points of the Micrometer, then 13 is to 1 as 100 to 7,7; therefore the Object is $\frac{1}{7.7}$ Part of a Line, or 77 make an Inch.

32. If the Image of another Object (by the same Magnifier) be equal to 7 Points of the Micrometer, then say, as 7 is to 1, so is 100 to 14,3 nearly; therefore the Object is $\frac{1}{14.3}$ Part of a Line, or 143 make an Inch.

33. If the Image equals just 10 Points of the Micrometer (with the same Lens) the Object will be just $\frac{1}{10}$ of a Line, or 100 make an Inch.

34. These Examples are more than sufficient to elucidate the Method of measuring all small Objects that can be rendered visible, or of any sensible Magnitude by the Microscope; and since each Point of the Micrometer DE, is by the ocular Lens, made equal to the *tenth* of an Inch, or a *whole Line*; it will not be difficult for any dextrous or discerning Person to be certain of the Measure of the Image not only in Points, but nearly to $\frac{1}{10}$ of a Point; so that by the Magnifier E, you may proceed in measuring the Diameter of any Object to nearly the 6400th Part of a Line; which is an amazing Degree of Accuracy.

35. But to effect this with still more Certainty, the Micrometer has Lines drawn upon it at every tenth Point, and therefore the Computation of the Number of Points in any large Image is much facilitated thereby;

by; and with respect to small Images, if they are equal and contiguous, or lie in Rows by each other; as the Lenses in the *Cornea* of an Insect's Eye, then it will be very easy to observe what Number of them are contained in 10, 20, 30, &c. of these Points, and from thence to determine the Breadth of one of them in Points, and Parts of a Point. And when there are Images enough you may take the whole Line FG, which contains 50 Points.

36. For Example; in the *Cornea* of the Eye of a small Sort of *Libella* (or Adderspear) there will (by the 3d Magnifier) be just 17 Images in FG, or 50 Points; then $50 : 17 :: 240 : 82$: the Lenses in one Line, or 820 in an Inch.

37. In another Experiment (with the same Lens, No. 3.) we find $10\frac{1}{2}$ square Lenses in the *Cornea* of a *Lobster's* Eye, just equal to 50 Points; then say as $50 : 10\frac{1}{2} :: 240 : 50\frac{1}{2}$ nearly, in a Line; or 505 in an Inch.

IV. Of the *Apparent* MAGNITUDE of OBJECTS.

38. It has been shewn, that the *Apparent* FIELD of VIEW in this Microscope is 64 Lines, or 6,4 Inches; therefore the *Apparent* MAGNITUDE of any Object will be the Number of these Lines that its Image equals upon the Micrometer; thus suppose the Image of an Object is equal to 1, or to 3, or to 7 of these Lines, then the *Apparent Magnitude* of such an Object will be equal to $\frac{1}{16}$, $\frac{3}{16}$, or $\frac{7}{16}$ of an Inch, seen at the Distance of 8 Inches from the Eye.

39. What has been said respects one Lens only; for in different Lenses the *Apparent Magnitude* of Objects will vary with their different *magnifying Powers*. In

my Microscope there are six Lenses which I shall denote by A, B, C, D, E, F; then suppose with the Lens B you observe the Image of an Object equal to 3 Lines, and in the Lens D you find it equal to 12 Lines on the Micrometer; then you know that by the Lens B the apparent Magnitude of that Object is $\frac{3}{12}$ of an Inch; and by the Lens D, it is 4 Times as much, viz. 1,2 Inch. After this Manner I have seen the circular Particles of human Blood with the deepest Magnifier F, from $\frac{4}{10}$ to $\frac{6}{10}$ Tenths of an Inch in Diameter.

40. The Ease and Expedition of a Computation of the real and apparent Magnitude of Objects, will be greatly promoted by a Table like the following, which I made for my own particular Use, whose Numbers are adapted to any Number of *Lines* under 20, in the several Lenses.

Lines	A	B	C	D	E	F
1	70	120	240	480	640	1280
2	35	60	120	240	320	640
3	23,3	40	80	160	213,3	426,6
4	17,5	30	60	120	160	320
5	14	24	48	96	128	256
6	11,7	20	40	80	106,7	213,3
7	10	17,2	34,3	68,7	91,4	182,8
8	8,75	15	30	60	80	160
9	7,78	13,3	26,7	53,3	71,1	142
10	7	12	24	48	64	128
11	6,4	10,9	21,8	43,6	58,2	116,3
12	5,8	10	20	40	53,3	106,7
13	5,4	9,2	18,4	36,8	49,2	98,4
14	5	8,6	17,2	34,4	45,7	91,4
15	4,7	8	16	32	42,7	85,4
16	4,3	7,5	15	30	40	80
17	4,1	7	14,1	28,2	37,6	75,2
18	3,9	6,6	13,3	26,6	35,5	71
19	3,7	6,3	12,6	25,2	33,6	67,2
20	3,5	6	12	24	32	64

41. The Use of this Table will be very easily understood by a few Examples; thus suppose the *apparent Magnitude* (or Image) of the Object by the Lens A be 5 Lines, or $\frac{1}{2}$ an Inch; then against 5 in the first Column, you see 14 under A, which shews, that 14 such Objects are contained in *one Line*; and consequently, that there are 140 in *one Inch*, or that one such Object is the $\frac{1}{140}$ Part of an Inch in Diameter.

42. Again, suppose with the Lens C you observe the Image of an Object equal to 13 *Lines* of the MICROMETER, then against 13 on the Side, you find the Number 18,4, which shew there are nearly $18\frac{1}{2}$ of such Objects in *one Line*, or that 184 are just equal to an *Inch*.

43. Let the apparent Magnitude, or Image by the Lens D equal $10\frac{1}{2}$ *Lines*; then add together the two Numbers 48 and 43,6 answering to 10 and 11 *Lines*, *half their Sum* will be 45,8, and is very nearly the Number of such Objects in a *Line*, or 458 in an *Inch*.

44. With the deepest Lens F, I have often found the Images of the Particles of *human Blood* equal to 6 *Lines*; consequently there will be 2133 in an *Inch*; and thus you proceed in all other Cases.

45. These Divisions of the MICROMETER would, however, be of little Use in the dark; and therefore the upper Part of the Microscope is so contrived as to throw a considerable Light upon the Micrometer, sufficient to render the whole compleatly visible, without the least Injury to the distinct Appearance of the Images of Objects in the Field of View.

46. Lastly, to render this Construction every Way compleat, the Micrometer DE is contained in a Tube which

which moves freely within another ; and by that Means it may be placed right across the Image of an Object to shew the Number of Points in its Diameter ; or it may be placed appositely and parallel to a Row of any equidistant Images, to compute how many of them are equal to a given Number of *Lines* and *Points* of the Micrometer.

V. The same CONSTRUCTION of a MICROMETER applied to a *Portable Solar MICROSCOPE*.

47. We view, with infinite Pleasure, the amazing large Appearances of very small Objects both *Transparent* and *Opaque*, in the SOLAR MICROSCOPE ; but we can view them only, being as yet destitute of any Means of measuring or computing the enormous Size of their Images on one hand, or of the *Minuteness* of the Objects themselves on the other, to any certain Degree of Accuracy.

48. Nor can such a Micrometer, as above described, (or any other indeed) be commodiously applied to the *Solar Microscope* at large, as usually applied in the *Camera Obscura*, or darkened Room ; but in a Solar Microscope of a small, portable Form, it may be very conveniently adapted, and all small Objects measured by it to a sufficient Degree of Exactness.

49. If the Height of the Object-Lens above the Bottom of the Box be about 10 or 12 Inches, it will allow of a *magnifying Power* from 100 to 300 or 400 Times, by the 3d, 4th, and fifth Magnifiers. But how much any particular Lens magnifies, is immediately known by the following Construction of this *portable Solar MICROSCOPE*.

50. Let

50. Let the Bottom be just 7 Inches square; then may the *Print of the Copper Plate* prefixed to this Tract (hitherto considered as the *magnified FIELD of VIEW* in the compound Microscope) be pasted upon it; and the MICROMETER DE will be here of the same Use as before; for the Micrometer Screw being placed as an Object just above the Lens or Magnifier at the Top, the Image thereof will be formed upon the Bottom very distinctly, and it will be easy to see *how many Points of the Micrometer DE are contained in one magnified Point AB* of the Object; for 10 Times that Number is the *magnifying Power* of that Lens.

51. Thus for Example: suppose the Lens I use make the Image of the single Point AB equal to 10 Points of the Micrometer DE, then because each of these Points is equal to a *Line*, or 10 natural Points; therefore AB is equal to 100 such Points, or is magnified 100 Times.

52. Again, suppose another Lens, still deeper, makes $AB = 32$ Points of DE, then it magnifies this, and every Object, 320 Times; and so for any other Lens.

53. When the magnifying Power is determined, the Mensuration of the small Object is known of course; for in the first Example, if 10 Points of the Micrometer DE be equal to one magnified Point AB, then 1 Point of DE will be $\frac{1}{10}$ of AB; but AB is $\frac{1}{100}$ of an Inch; therefore every Point in DE is $\frac{1}{1000}$ of an Inch, or $\frac{1}{100}$ of a Line. Suppose then, that by such a Lens the Image of a small Object were to be observed to equal $2\frac{1}{2}$ Points of the Micrometer DE, then the Diameter of the said Object will be equal to $\frac{2\frac{1}{2}}{100}$ or $\frac{1}{40}$

of a Line ; or 40 of them laid contiguous to each other, will equal *one Line*.

54. After the same Manner in the 2d Example, since 32 Points are contained in AB, one Point will be $\frac{1}{32}$ of $\frac{1}{100}$, or $\frac{1}{3200}$ of an Inch, or $\frac{1}{320}$ of a Line ; therefore if an Image of an Object by this Lens covers $2\frac{1}{2}$ Points of the Micrometer DE, its Diameter will be $\frac{2\frac{1}{2}}{320}$, or $\frac{1}{128}$ Part of a Line ; and so on for others.

55. I apprehend 4 Magnifiers will be sufficient for this *Portable Solar Microscope*, which may be about $\frac{1}{3}$, $\frac{1}{10}$, $\frac{1}{20}$, $\frac{1}{30}$ of an Inch focal Distance ; with the last of these I can see the Image of a human Hair 6 Lines in width ; the Lenses in the Eye of the Adderspear 4 Lines, and those in the Eye of a Lobster 5 Lines, or half an Inch wide. The Claw of a Louse is 17 Lines long ; and even the Particles of Blood are very distinct, and easily measured on the Points of the Micrometer DE. Though in my Instrument the Distance of the Magnifiers is not more than 8 Inches from the said MICROMETER.

56. With respect to this *Portable Solar Microscope*, it will be necessary to have a Contrivance to give a requisite Degree of Light for each particular Lens ; and make the Field or Circle of Light on the Bottom of the Box equal to that of the Print nearly ; and for this Purpose a proper Apparatus is adapted to the Instrument, and gives no Trouble in the Use of it.

57. After having described the Application of the MICROMETER to the *Solar Microscopes*, I shall only just observe, I mean that which shews *transparent Objects* only ; but if the *Virtuoso* shall chuse to be at the Expence, he may likewise have it adapted to an *Opake Solar*

Solar Microscope, of a *portable Form*, the same Box serving for both, with only a different Apparatus on the Top, for shewing opake Objects on the Paper, with the *engraved MICROMETER* upon it on the Bottom.

58. The Method of *measuring opake Objects* does no Way differ from that for *Transparent Ones* already described (Art. 50, &c.) For the original Screw of 100 Threads, or Points, to an Inch, being itself an *opake Object*, will be an excellent Experiment of this Kind; all its Points, together with the whole Surface, being so strongly illuminated, will form a splendid Image upon the Paper, where it will be easy to see how many of the Points of the Micrometer DE are contained in One, or rather in Ten of those of the Image; and then you will know what Part of an Inch *one Point* of the Micrometer measures; as before was shewn for *transparent Objects*.

59. But the principal Point in View here, is the curious and delightful Appearance opake Objects make when illuminated and magnified in this Way; but for a more particular Account of this Matter, I shall refer the Reader to my *Description of the Opake Solar MICROSCOPE at large*, in a former Pamphlet.

60. The brass *Apparatus* for this portable Opake Solar Microscope, makes one of the very best Sort of MEGALASCOPIES for opake Objects, viz. those from about $\frac{1}{4}$ to $\frac{3}{4}$, or 1 Inch, Diameter; there are some FOSSILS and ORES which, when viewed this Way, are beyond Expression beautiful. When I view that curiously coloured Copper Ore, called the PHEASANT'S EYE, the Glory, Richness, and Variety of Colours, exceed Conception, and elude the Force of Words to describe; the Whole seems expanded into a capacious

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and transparent Scene; and I know of nothing that bears any distant Resemblance to it. This Experiment is superlatively fine by CANDLE-LIGHT. I shall just mention some other Uses to which this little Box may be applied by Way of a portable or artificial *Camera Obscura*.

61. Thus in this Machine you not only exhibit a pleasing Appearance of every minute Object, and take all its Dimensions with Exactness by the MICRO-METER, but you may also draw the Images of any of those Objects with the utmost Ease and Readiness, by proper Apertures made in the Sides of the Box; one of which gives a View of the Image, and the other allows Freedom of Motion in the Hand that draws it. Thus a noble *Collection of Drawings* of the magnified and magnificent Pieces of Nature's Workmanship in *original Miniature*, may be obtained in little Time, in the Way of Amusement only, (attended with the highest Pleasure and Dignity,) by any ingenious Hand.

62. In the same Machine, instead of the *Solar Apparatus*, another may be applied for delineating a Picture of all Objects before it in a most pleasing *Landscape View*, whether of *Streets, Gardens, Fields, Mountains, Vallies, &c.* with the natural *Lights and Shades*, enlivened with *Motion*, and conformable to the exactest *Laws of Perspective*. Thus Specimens of Painting by the Pencil of Nature may be formed at Pleasure, to gratify both the *Eye of the Body and the Mind* at the same Time. Pictures as much superior to the Paintings of *Apelles*, as *Light* is superior to *gritty Earth*.

63. It may not, perhaps, be thought worth while to observe, that this Machine will also admit of a Contrivance or *Apparatus* for viewing *Perspective Prints*, or *Landscapes*, in *Alto Relievo*, as in those called *Optical Machines*.

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64. The Solar Apparatus is of itself an excellent *Wilfion's Microscope* in one Part; and the best Sort of *Flower or Fossil Microscope* in the other; so that in this Machine every Sort of Object, great or small, may be distinctly seen, contemplated, and measured with the greatest Satisfaction and Nicety.

65. What adds still more to its Commendation, is, that it may be used in a Room with the Windows open, the Body of the Box being internally black, is, itself, a sufficient *Camera Obscura*.

66. The Images formed by this Instrument may be viewed either with the naked Eye, or through a Plano-Convex Lens; in the latter Case they will not only be magnified more, but will appear with such *Relievo* as to excite an Idea so very naturally and exactly corresponding to the Object itself, that you would think it was really the same which you saw.

67. For the greater Convenience of measuring Objects, a Piece of Pasteboard might be cut exactly to the Size of the Bottom of the Box, and its Center found by two diagonal Lines; on this Center, the Center of the printed circular Field of View D H E I must be placed, with a strong thread passing through both, connecting them together, and yet admitting Freedom of Motion to the said Circle; by this Means the Micrometer DE may be turned about, and often adjusted to the Image, when the Image cannot be so readily brought to the Micrometer.

68. In the last Place, those who chuse it, may have a small *Reflecting TELESCOPE* adapted to the Top of the Box for forming the SUN'S IMAGE at the Bottom, in which the Solar *Maculae* may at any Time be viewed, with their various Alterations and Changes that daily happen,

happen, without poring through the dark Glafs of a Telescope for that Purpose.

69. In this Way also, you may make an excellent *Solar-Disk* MICROSCOPE for shewing all transparent Objects most delightfully upon the Solar Disk, or bright Face of the Sun, on the Bottom of the Box. Also by Means of the Micrometer DE, the skilful Astronomer will easily measure the DIAMETER of the SUN to a Second; and perhaps he will find this the most ready and useful HELIOMETER of all others.

70. I have now said all I think material or necessary concerning this *New Construction* of a MICROMETER in the *Compound and Solar* MICROSCOPES, which are by this Means adapted to afford the greatest Pleasure, and the noblest Amusement to every rational and studious Observer of the boundless Scenes in the most striking and stupendous Operations of Nature, every where visible about us by these Glasses; which, as I have elsewhere observed, are a perpetual COMMENTARY on the BIBLE of NATURE, and enlarge the Mind with a constant Influx of the most useful Knowledge, which naturally and necessarily inspires the purest Principles of Piety and Devotion to the adorable Creator, and Governor of the Whole.

E R R A T A.

Page 4, line 17, instead of *single*, read *single* LENSES.

Page 5, line 9, instead of MICROSCOPE, read LENSES.

F I N I S.



